terms are sufficiently accurate, the third stage of the controller yields a cancellation of the nonlinear terms in Equation 26. The resulting behavior of the physical exoskeleton is thus given by

$$\ddot{q}=\alpha_c-I_e(m_e,q)^{-1}\tau_p \tag{29}$$

The above equation shows that the exoskeleton's kinematic response $\ddot{q}$ is linear to the inputs α_c (control) and $-\tau_p$ (interaction torque).

Although the invention has been described in considerable detail with reference to certain embodiments thereof, other embodiments are possible as will be understood to those skilled in the art.

What is claimed is:

1. A method for controlling an actuator of an exoskeleton with a controller, comprising:

the controller receiving a desired mechanical impedance function of the exoskeleton, the desired mechanical impedance function comprising a desired relationship between forces applied to the exoskeleton and resulting angular velocities of the exoskeleton at various frequencies;

the controller receiving a measured interaction force, wherein the measured interaction force represents an interaction between the exoskeleton and a limb segment of a user wearing the exoskeleton; and

controlling a kinematic trajectory of the actuator with the controller based on the measured interaction force using impedance control to implement the desired mechanical impedance function of the exoskeleton,

the desired mechanical impedance function of the exoskeleton being an active impedance function that causes the exoskeleton to be assistive to the user wearing the exoskeleton by reducing a muscle torque required to move the limb segment, the desired mechanical impedance function comprising a negative exoskeleton impedance component, wherein the negative exoskeleton impedance component is determined by estimating a limb impedance component of the limb segment of the user and by negatively scaling the estimated limb impedance component based on a degree of reduction of the muscle torque required to move the limb segment.

2. The method of claim **1**, wherein the negative exoskeleton impedance component comprises one from the set of: a negative desired inertia moment of the exoskeleton, a negative desired damping of the exoskeleton, and a negative desired stiffness of the exoskeleton.

3. The method of claim **2**, wherein the negative exoskeleton impedance component is out of phase with a limb impedance component of the limb segment of the user by 180 degrees.

4. The method of claim **1**, wherein the kinematic trajectory of the actuator comprises an angular velocity of the actuator.

5. A method for controlling an actuator of an exoskeleton with a controller, comprising:

the controller receiving a desired mechanical impedance function of the exoskeleton, the desired mechanical impedance function comprising a desired relationship between forces applied to the exoskeleton and resulting angular velocities of the exoskeleton at various frequencies;

the controller receiving a measured angular velocity of a limb segment of a user wearing the exoskeleton; and

controlling a force of the actuator with the controller based on the measured angular velocity using impedance control to implement the desired mechanical impedance function of the exoskeleton,

the desired mechanical impedance function of the exoskeleton being an active impedance function that causes the exoskeleton to be assistive to the user wearing the exoskeleton by reducing a muscle torque required to move the limb segment, the desired mechanical impedance function comprising a negative exoskeleton impedance component, wherein the negative exoskeleton impedance component is determined by estimating a limb impedance component of the limb segment of the user and by negatively scaling the estimated limb impedance component based on a degree of reduction of the muscle torque required to move the limb segment.

6. The method of claim **5**, wherein the negative exoskeleton impedance component comprises one from the set of: a negative desired inertia moment of the exoskeleton, a negative desired damping of the exoskeleton, and a negative desired stiffness of the exoskeleton.

7. The method of claim **6**, wherein the negative exoskeleton impedance component is out of phase with a limb impedance component of the limb segment of the user by 180 degrees.

8. A controller for controlling an actuator of an exoskeleton, the controller comprising:

a processor; and

a computer-readable storage medium storing computer program modules executable on the processor, the modules configured for:

receiving a desired mechanical impedance function of the exoskeleton, the desired mechanical impedance function comprising a desired relationship between forces applied to the exoskeleton and resulting angular velocities of the exoskeleton at various frequencies;

receiving a measured interaction force, wherein the measured interaction force represents an interaction between the exoskeleton and a limb segment of a user wearing the exoskeleton; and

controlling a kinematic trajectory of the actuator based on the measured interaction force using impedance control to implement the desired mechanical impedance function of the exoskeleton,

wherein the desired mechanical impedance function of the exoskeleton being an active impedance function that causes the exoskeleton to be assistive to the user wearing the exoskeleton by reducing a muscle torque required to move the limb segment, the desired mechanical impedance function comprising a negative exoskeleton impedance component, wherein the negative exoskeleton impedance component is determined by estimating a limb impedance component of the limb segment of the user and by negatively scaling the estimated limb impedance component based on a degree of reduction of the muscle torque required to move the limb segment.

9. The controller of claim **8**, wherein the negative exoskeleton impedance component comprises one from the set of: a negative desired inertia moment of the exoskeleton, a negative desired damping of the exoskeleton, and a negative desired stiffness of the exoskeleton.

10. The controller of claim **9**, wherein the negative exoskeleton impedance component is out of phase with a limb impedance component of the limb segment of the user by 180 degrees.

11. The controller of claim **8**, wherein the kinematic trajectory of the actuator comprises an angular velocity of the actuator.